# SENSORS & CONTROLS

Project Fact Sheet

## On-Line Sensors for Emissions Monitoring

### Benefits

- High responsivity to operate over the 100-1,000 ppm range of greatest interest
- Rapid response time to permit use in real-time process control applications
- High stability to withstand in-situ monitoring in high-temperature and corrosive environments
- Easily varied film composition and microstructure to optimize selectivity to a wide range of analytes
- Materials and processing choices to enable packaging design and device costs comparable to well established oxygen sensors

### Applications

The thick-film gas sensors are targeted toward use in monitoring air pollution from industrial processes and transportation applications, including:

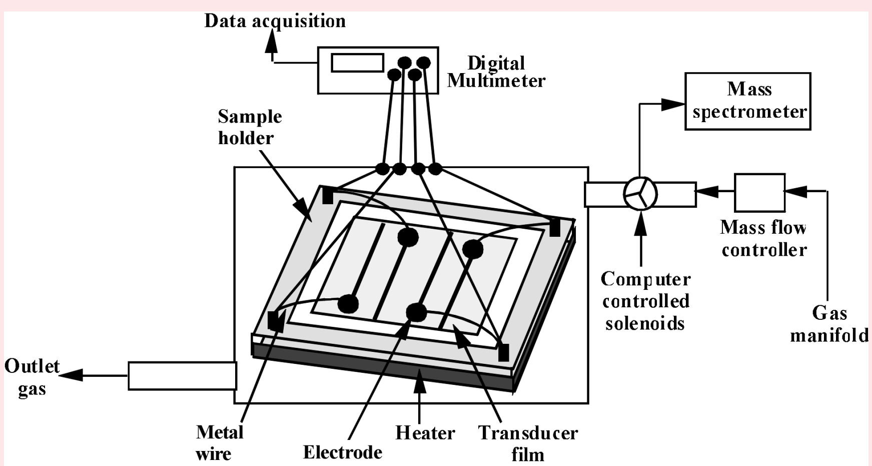
- oil and coal burning in the electric power industry,
- chemical and petroleum refining coal distillation,
- stationary, heavy-duty diesel engines for power generation,
- kilns, boilers, furnaces, and incinerators used in the glass, steel, aluminum, and metalcasting industries, and
- automotive emissions compliance.

## Robust chemical sensors will provide on-line monitoring of hydrocarbon and nitrogen oxide emissions in aggressive process streams

Robust chemical sensors will serve as a key component of automated control systems that will enable real-time control of hydrocarbon and nitrogen oxide ($NO_x$) emissions as well as improve energy efficiency in many energy-intensive operations. Hydrocarbons and $NO_x$ are smog precursors; additionally, hydrocarbon emissions are regulated as tropospheric ozone precursors and greenhouse gases. The novel sensor technology, based on high-surface-area transition metal carbide materials, is sensitive, fast, and amenable to miniaturization. These properties make the new sensor(s) desirable over current devices, including electrochemical, spectroscopic, and other solid-state detection technologies.

The electronic resistance of the new metal carbide materials strongly depends on surface interaction with targeted analytes. The thick-film sensors made from the new materials are highly selective and stable in high-temperature and corrosive environments. The sensors could lead to new markets associated with abatement or process control technologies for large numbers of smaller-scale emission sources. Additionally, the transition to more efficient lean-burn combustion processes could also be expedited with the development of improved technologies to monitor and control $NO_x$ emissions.

### Test Chamber




Schematic of Phase II second generation test chamber.

## Project Description

**Goal:** Develop and demonstrate robust, solid-state gas sensors to selectively detect $NO_x$ and hydrocarbon gas(es) at concentrations as low as the 50-ppm level.

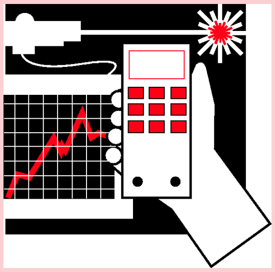
This project will evaluate and optimize high-surface-area metal carbide films as transducers for use in hydrocarbon and $NO_x$ sensors. The transducer performance will be optimized with respect to sensitivity, selectivity, stability, and response time. Several metal carbides will be evaluated for their respective selectivity and sensitivity to hydrocarbon gases and $NO_x$. Stability in the presence of oxidizing gases is of principal interest as most of the target process streams contain significant amounts of $O_2$, $H_2O$, and $CO_2$. Hence, various film processing conditions and/or dopants will be explored to improve the oxidation resistance. The response time and sensitivity are strong functions of the microstructural characteristics including film thickness, surface area, pore size, and pore geometry—these will be varied by changing the film fabrication conditions.

The prototype sensors will be fabricated and tested to have the following characteristics:

- a 20% change in response to the presence of 50-ppm target gas ($NO_x$ or hydrocarbon),
- a high selectivity in the presence of common, combustion background gases,
- the reversibility and stability of response during long-term cycling, and
- a response time of < 10 seconds.

## Progress and Milestones

- This two-year project was awarded a Phase II Small Business Innovation Research (SBIR) grant in June 1998.
- The project demonstrated the feasibility of using high-surface-area carbide films as transducers in hydrocarbon sensors during the Phase I SBIR grant. In a related project, the sensitivity and selectivity of carbide films for NO detection was demonstrated.
- Progress to date includes development of a method of making sensor films and identification of several sensing film materials that give a highly reproducible response to $NO_x$ and hydrocarbons.
- Evaluate and identify the best materials for $NO_x$ and hydrocarbon sensors with respect to overall performance by June 1999.
- Optimize overall performance for $NO_x$ and hydrocarbon sensors by December 1999.
- Complete the project with design, fabrication, and evaluation of prototype devices at the EPA Motor Vehicle Emissions Laboratory and the General Motors-Delphi facility by June 2000.



### Project Partners

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January 1999